The CleanEra Project:

Hamburg
November 1, 2007

Kees de Koning
Programme board DELcraFTworks

DELcraFTworks ...

TU Delft
Delft University of Technology

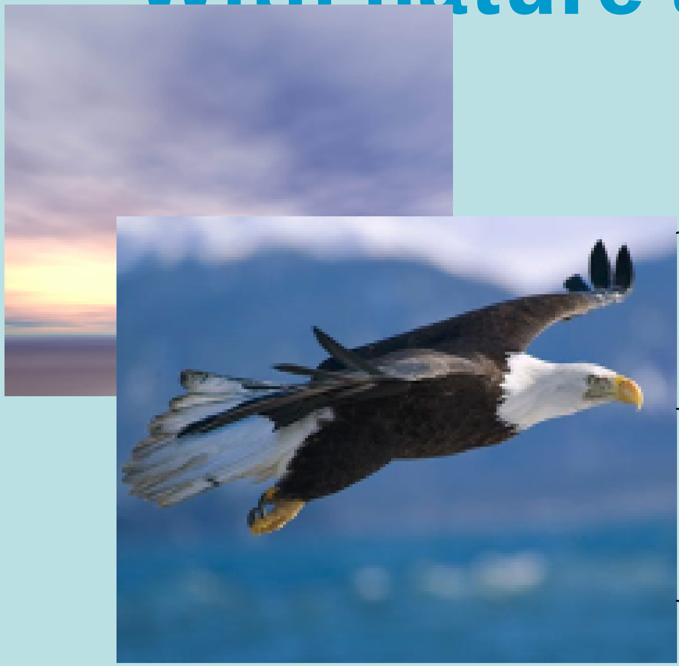
Contents

- **Breakthroughs in aviation**

- **Challenges for air transport and Europe's future aeronautics ("Vision 2020")**

- **DELcraFTworks, CleanEra Project**

A dream.....
With nature as inspiration:



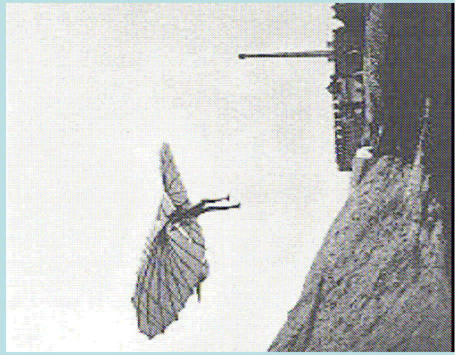
Daedilus & Icarus

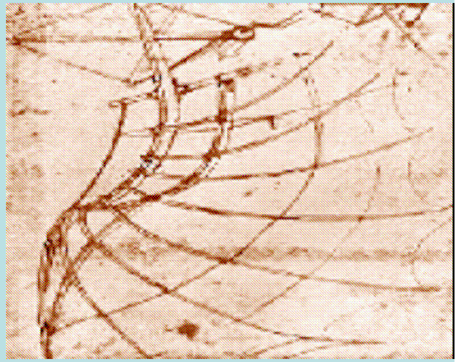
Leonardo da Vinci

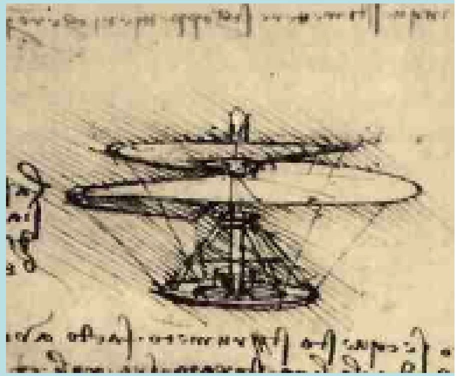
(1452-1519)

Otto Lilienthal

(1848-1896)



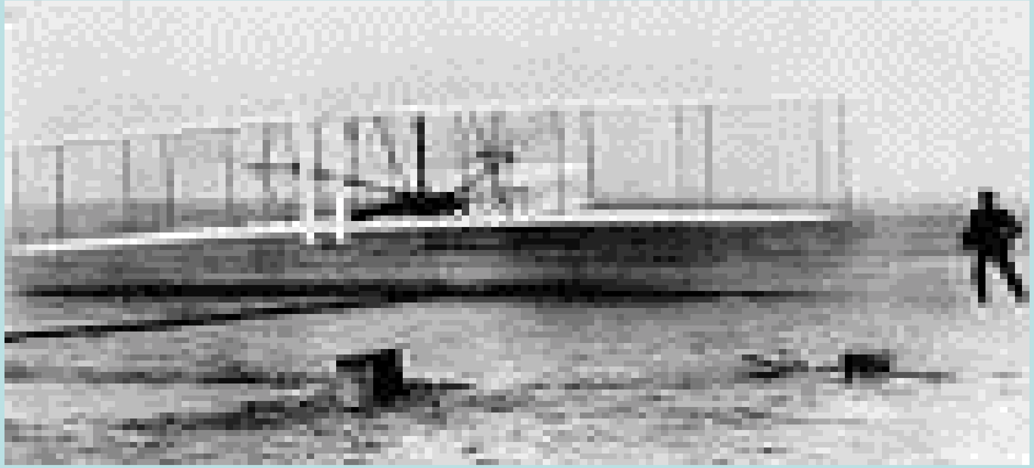




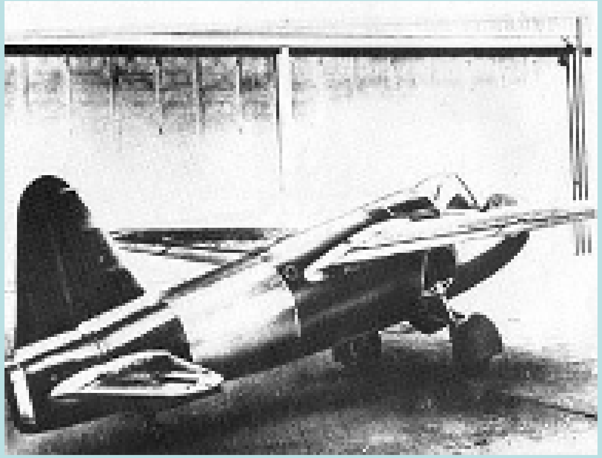
Breakthrough

Separation of the

lift and thrust function

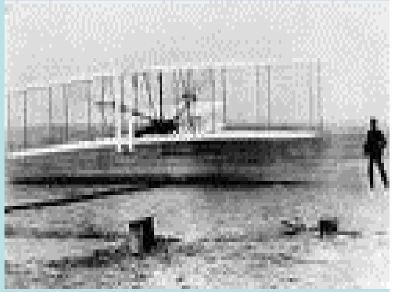


Pioneers: technical development by trial and error

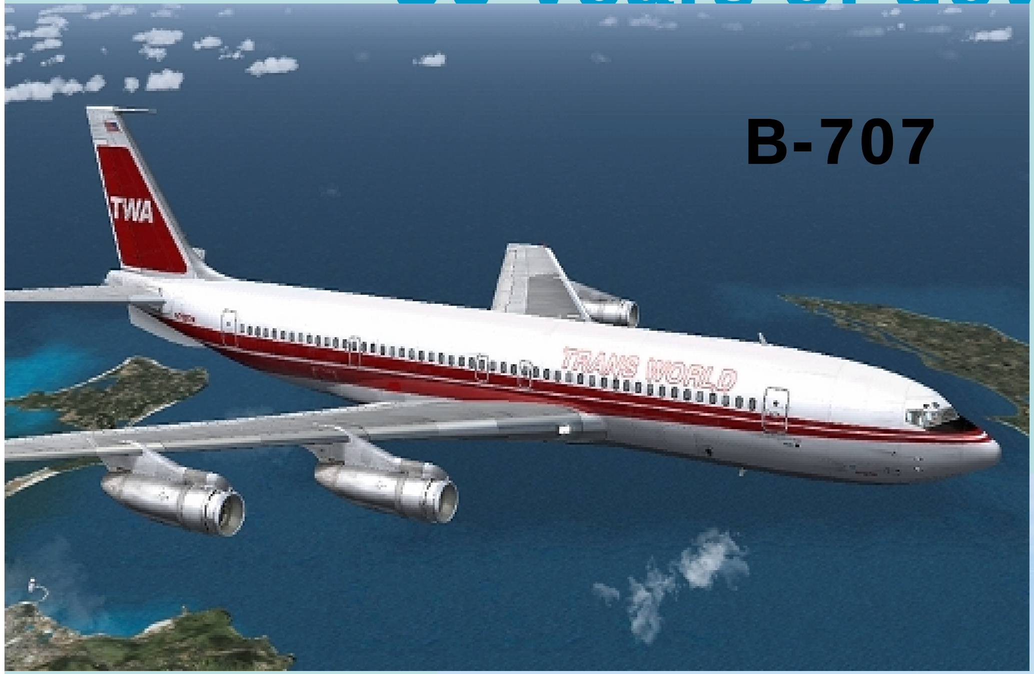


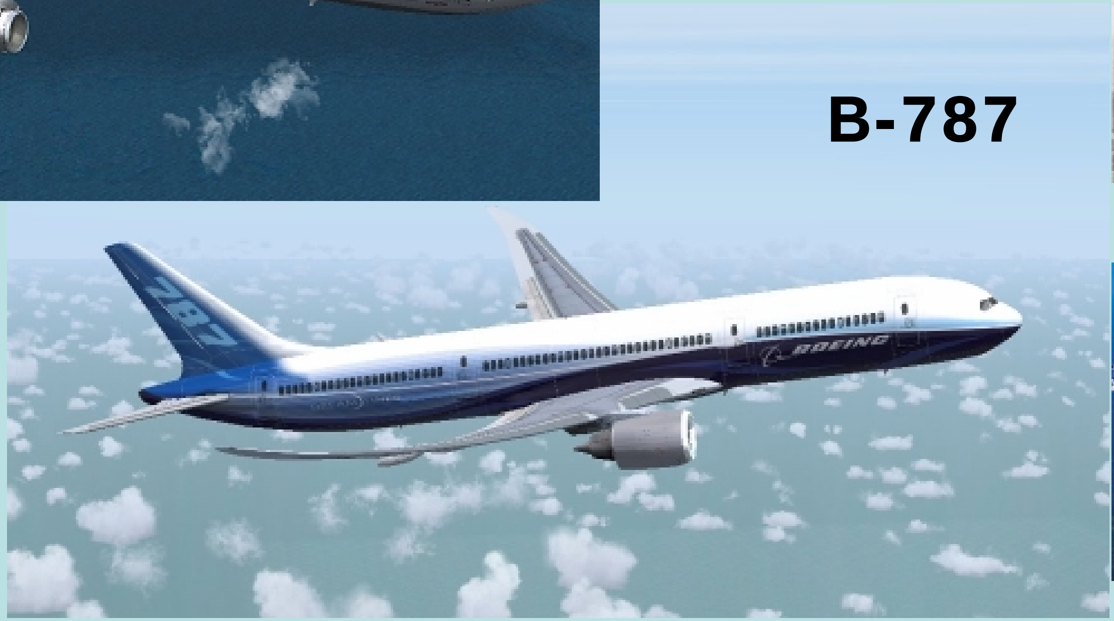
The first 50 years

- Enormous technological advance in design and manufacturing
- Shift to a large scale manufacturing early 20’s
- First jet powered aircraft in 1939: Heinkel He 178
- Integration of technology and science
- Development of jet engines in the 40’s



50 years of development





Development based on 1 concept

- In 50 years the aircraft concept did not change!!!!
- Within the same concept development:
  - Increased bypass ratio of engine
  - new materials (composites)
  - Improvement of design methodologies
  - Introduction of fly-by-wire

- Other concepts were not explored commercially

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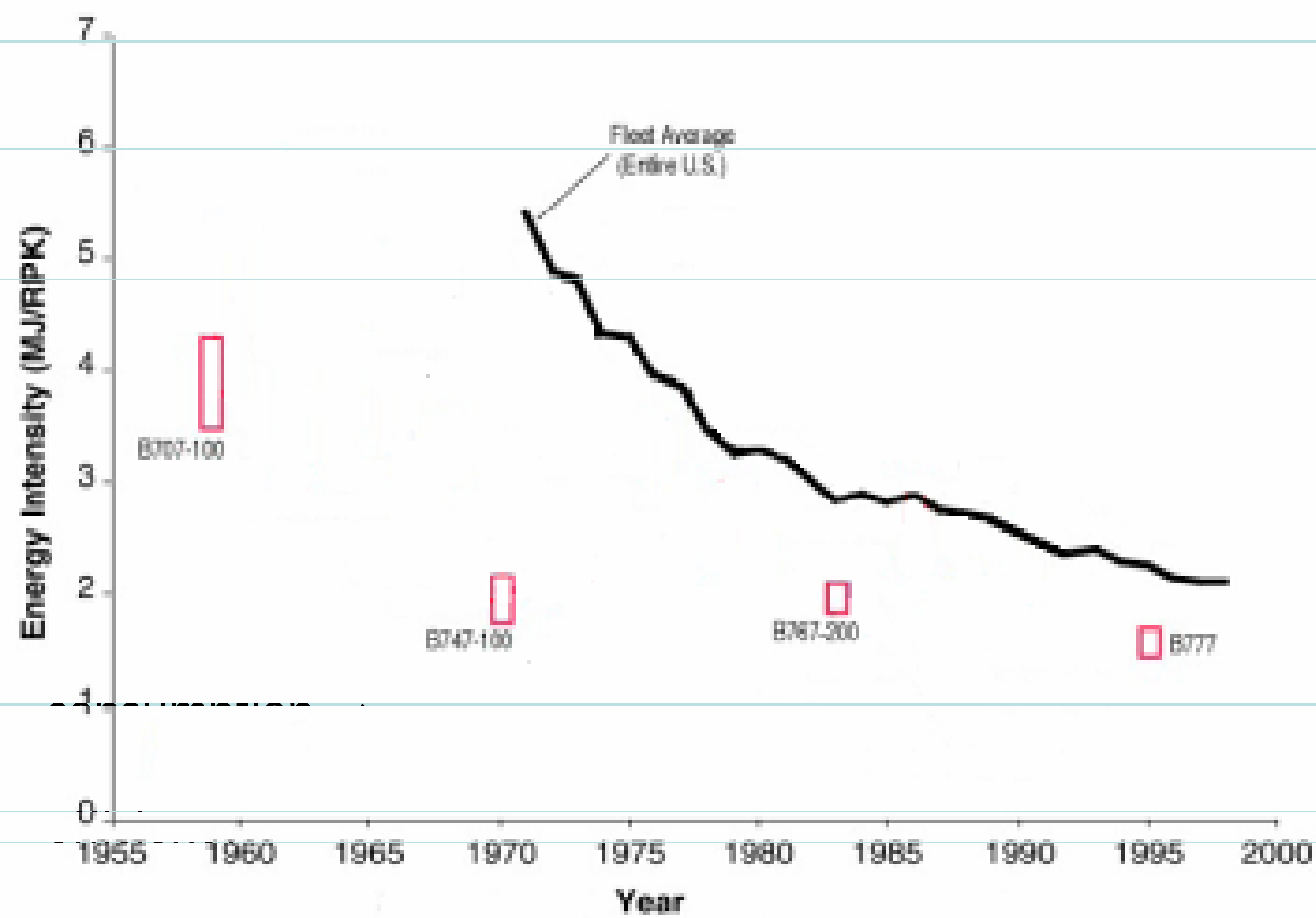
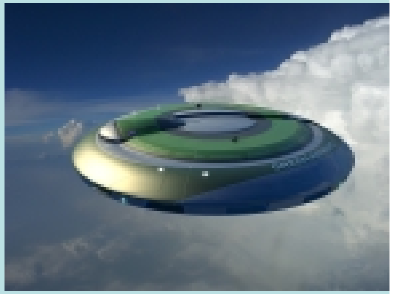
Revolutionary Designs in the Military Aircraft Industry

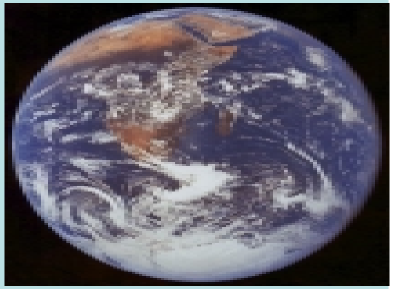
- Military aircraft industry has explored more revolutionary designs such as:

  - Dynamically unstable aircraft: F-16
  - High altitude: SR-71 Blackbird
  - Blended wingbodies: B-2

Efficiency of Current Airplanes (1)







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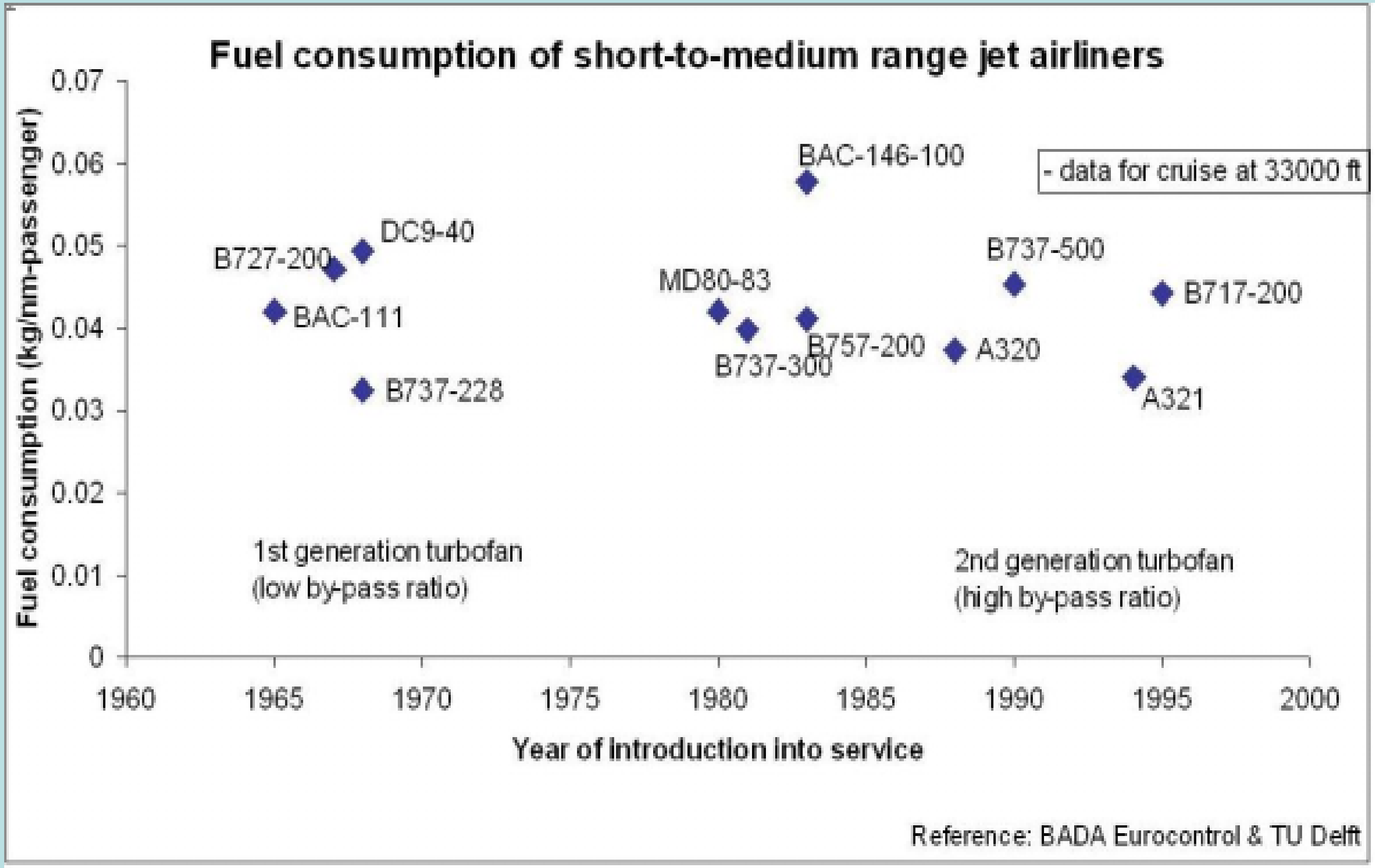
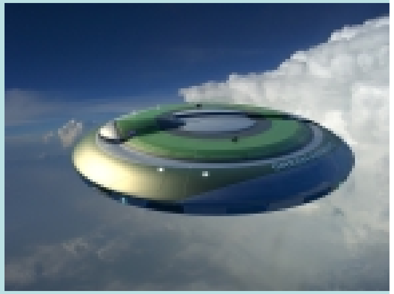
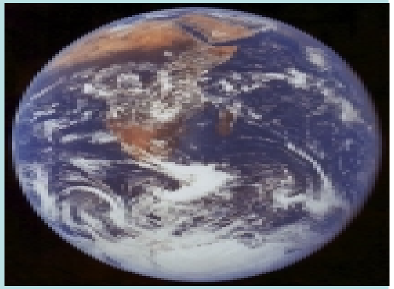
Efficiency of Current Airplanes (2)







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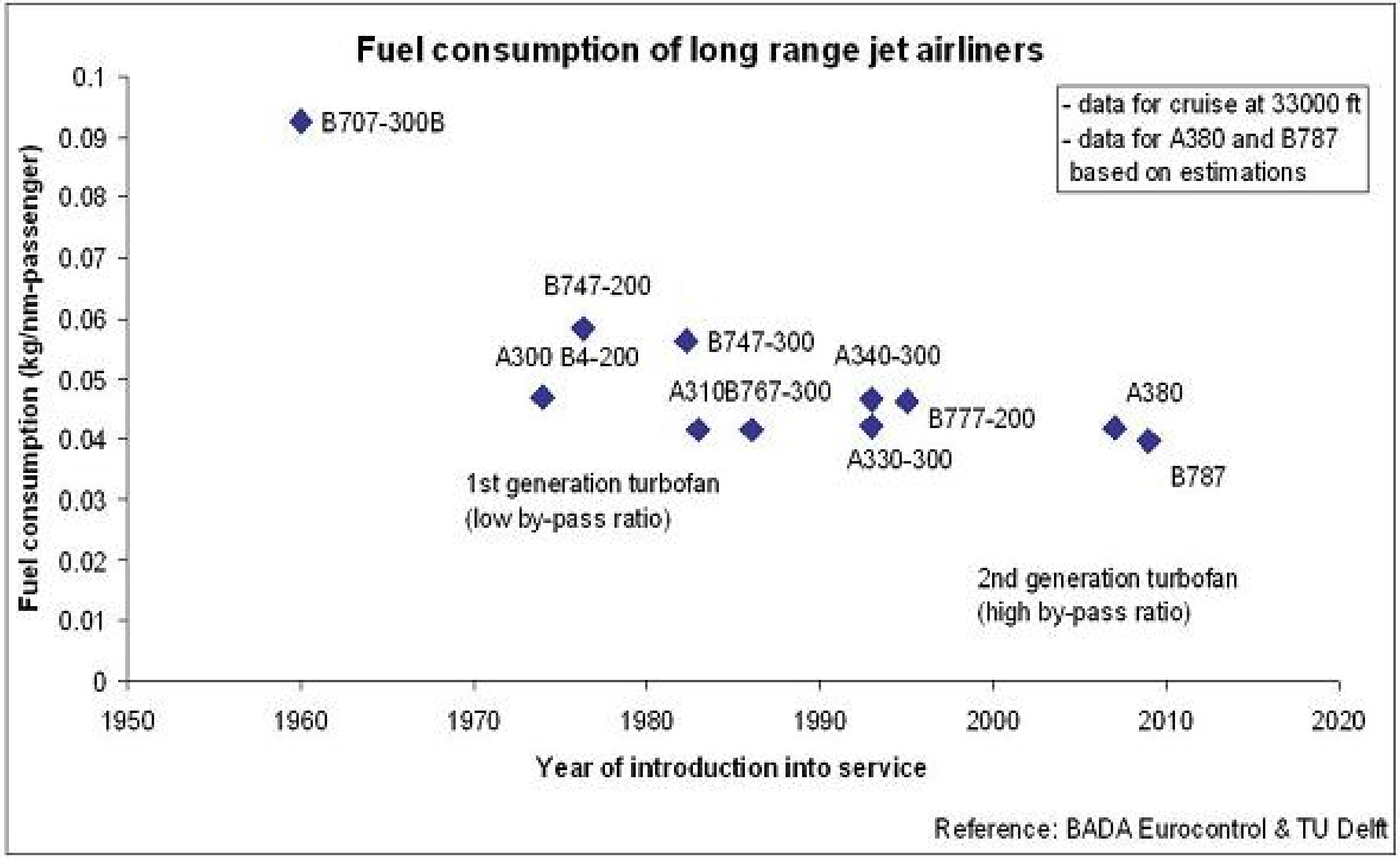
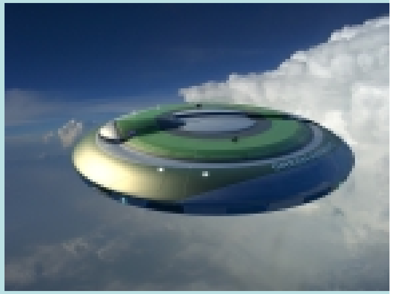
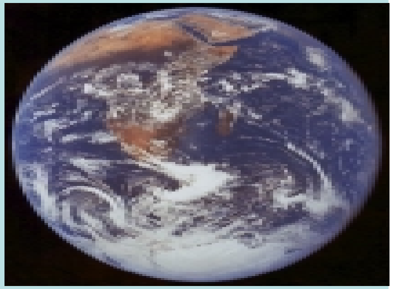
Efficiency of Current Airplanes (3)







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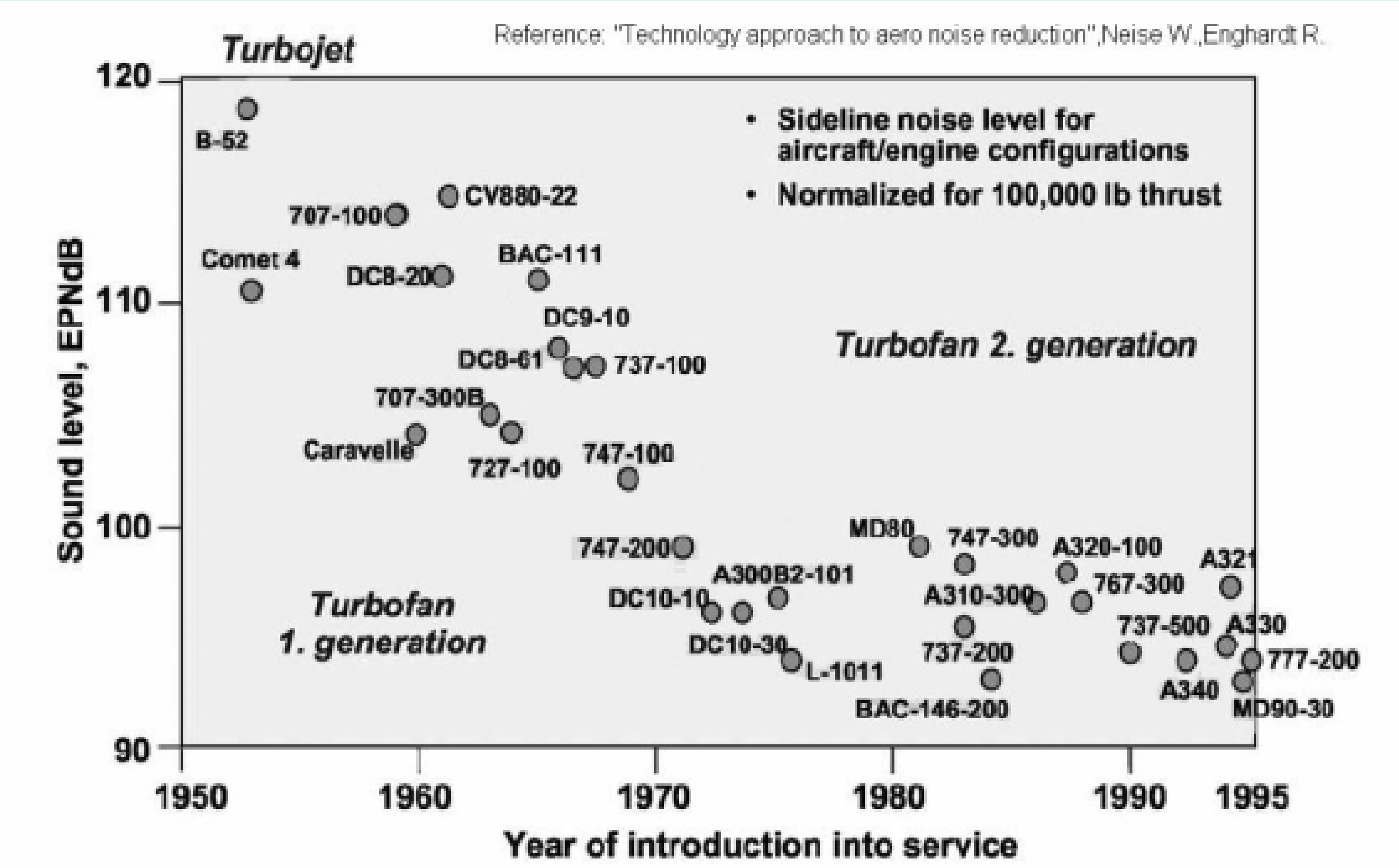
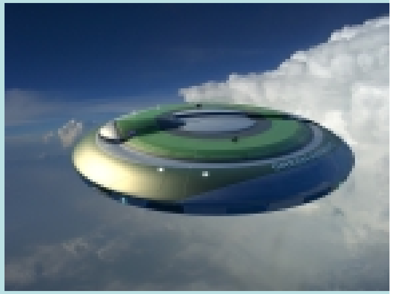
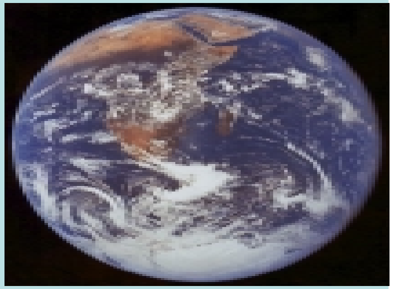
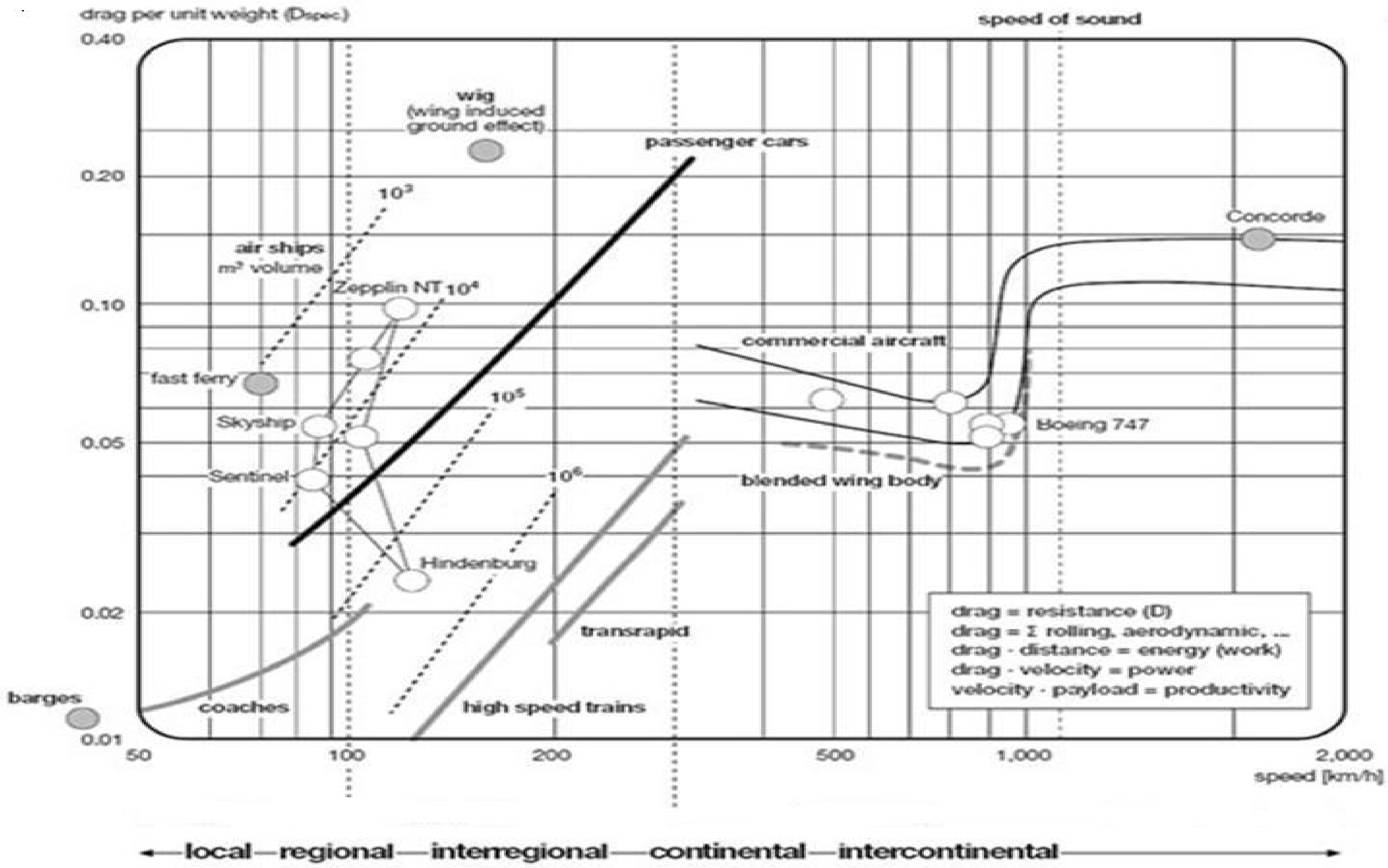
Aircraft noise level







PROVEN AND FUTURE TRANSPORT SYSTEMS		
Velocity domain (km/h)	**transport market/system**	**specific drag D_{spec} -**
50 < V < 100	local: Busses, Cars, Trains	0.01 - 0.03
50 < V < 250	local, regional and continental: Busses, Cars	0.01 - 0.20
125 < V < 300	regional and continental: high speed trains	0.01 - 0.05
300 < V < 900	regional, continental, intercontinental: subsonic aircraft	0.05 - 0.08
EXOTIC TRANSPORT SYSTEMS		
V > 1000	intercontinental: supersonic aircraft	0.10 - 0.15
V < 150	regional: Wings in ground effect	0.20 - 0.30
V < 120	regional: Airships	0.02 - 0.25


drag per unit weight (Dspec)
0.40
0.20
0.10
0.05
0.02
0.01
speed of sound
wig
(wing induced
ground effect)
passenger cars
10^3
air ships
m^3 volume
Zepplin NT
10^4
fast ferry
10^5
Skyship
Sentinel
10^6
Hindenburg
Concorde
commercial aircraft
Boeing 747
blended wing body
transrapid
barges
coaches
high speed trains
drag = resistance (D)
drag = Σ rolling, aerodynamic, ...
drag · distance = energy (work)
drag · velocity = power
velocity · payload = productivity
50
100
200
500
1,000
2,000
speed [km/h]
local — regional — interregional — continental — intercontinental

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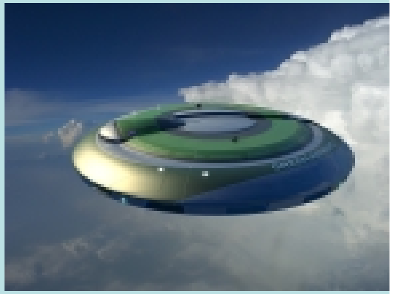
state of the art transport vehicles	$W_{empty} / W_{payload}$ *(indicative)*	
busses cars	2.5 3 (12) 8 (27)	dominated by propulsion and system typical European midsize car Mercedes S-Class
subsonic aircraft	4	balanced division of weight components
intercity trains	10	value dominated by structural weight
supersonic aircraft	12	value dominated by propulsion, systems and fuel weight
global orbit	66	value dominated by fuel weight
lunar orbit	500	value dominated by fuel weight

Challenges for Air Transport

Triple increase in air transport in next 20 years

↓



Current concept has little potential for improvement

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Need for revolutionary designs

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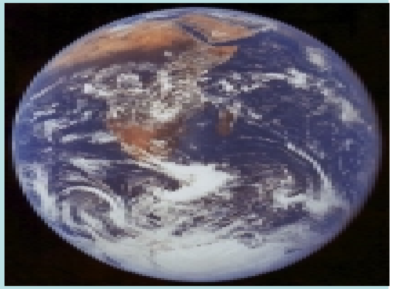

Out-of-the-box thinking

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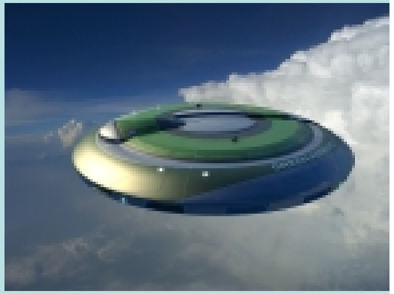
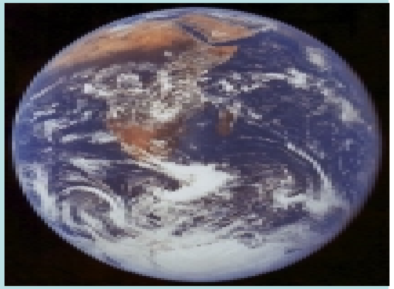
Vision 2020 for Europe's Future Air Transport*, What do we need?

- The 'greening' of air transport
  (fuel, emissions, noise)
- Increased time efficiency



- Increased customer satisfaction and safety
- Improved cost efficiency
- Better protection of aircraft and passengers

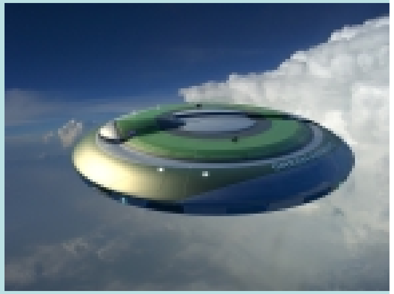


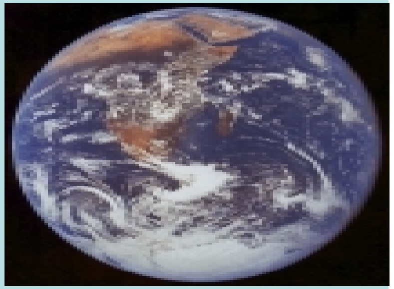
- Total air transport system approach

*** As defined by ACARE**

Vision 2020

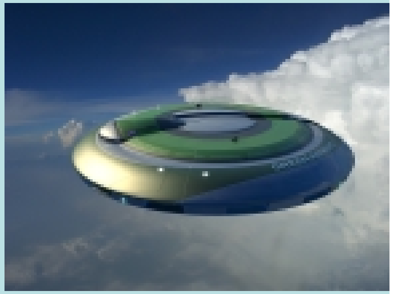
"An aircraft and an air transport system meeting society's needs, despite a three-fold increase in air transport"



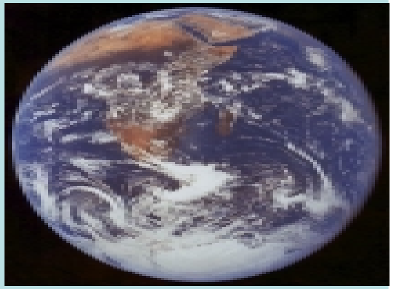


Goals for ‘Vision 2020’

Quality



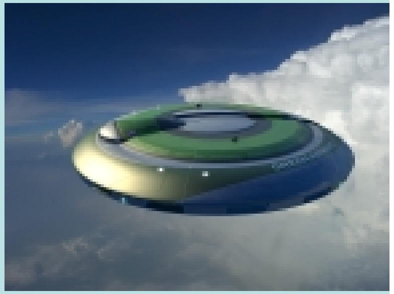
- * 99% of all flights arriving and departing within 15 minutes of the published timetable, in all weather conditions
- * No more than 15 minutes in the airport before departure and after arrival for short-haul flights and 30 minutes for long-haul flights
- * Passenger’s choice in comfort

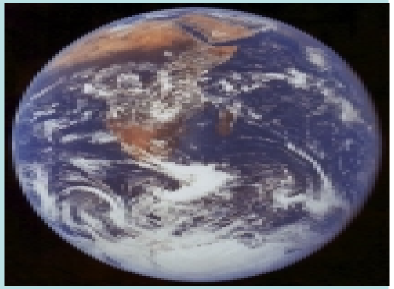


Goals for 'Vision 2020'

Safety

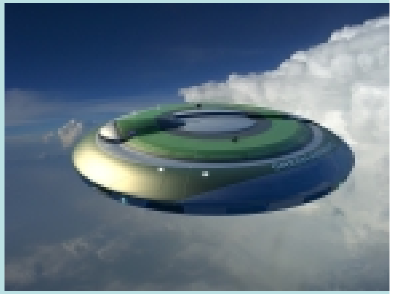
* A five-fold reduction in average accident rate
* Reduction of the impact of human error
* Higher standards of training



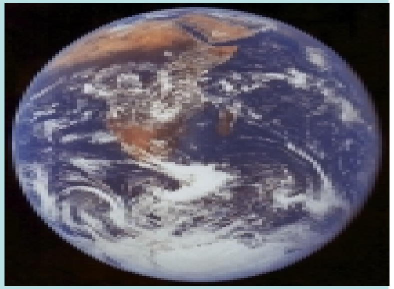


Goals for ‘Vision 2020’

Environment



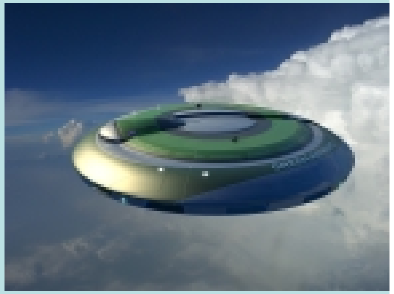
* Reduction in perceived noise levels of 50%
* 50% reduction of CO_2 and 80% of NO_x emissions
* Eliminate noise annoyance outside the airport boundary

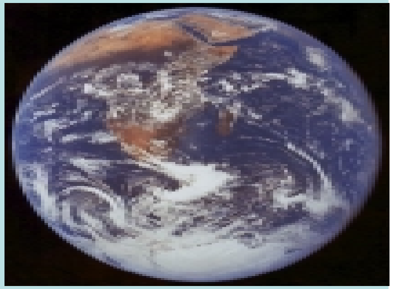


Goals for ‘Vision 2020’

Air transport system

* Air traffic management system that can handle 16 million flights a year with 24-hour operation
* European air traffic management system mainly based on a civil global satellite system
* Integration of air transport into an efficient multimodal transport system





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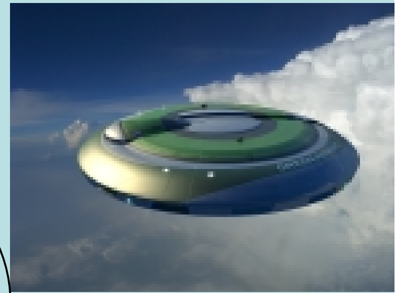
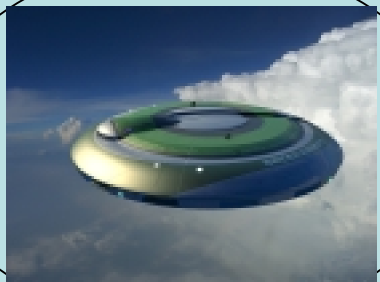


Out-of-the-box thinking



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The CleanEra Project

Cost-effective Low Emissions and Noise Efficient Regional Aircraft

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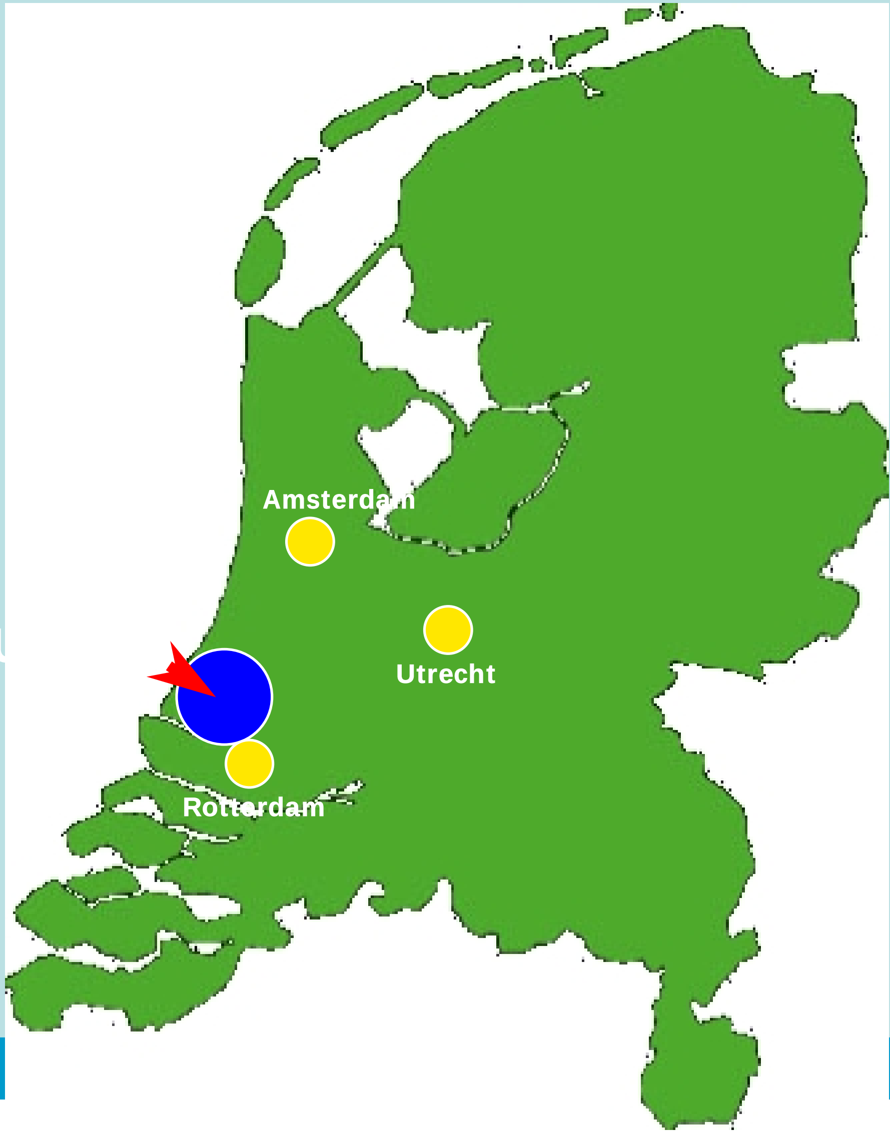
Delft University, the Netherlands



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Delft University
Faculty of Aerospace Engineering

Number of staff:

- 368 academic staff
- 112 support staff
- 135 PhD researchers

Number of students:

- 1700+ students (BSc & MSc)
- 400-450 first year students each year

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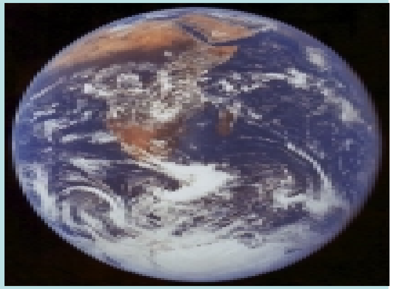
Delft University
Faculty of Aerospace Engineering
Research Facilities

- Simona: Advanced flight simulator

- Cessna Citation: Flying classroom research facility
- Subsonic, transonic, hypersonic windtunnels



- Structures and materials laboratory
- Geo Information laboratory

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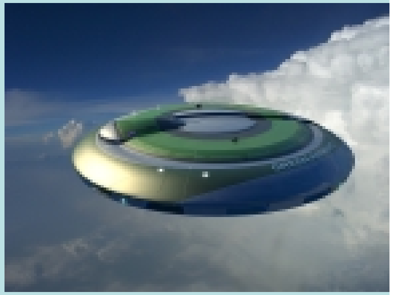

Mission statement

"To develop new technologies for (a) revolutionary conceptual aircraft design(s) optimized for environment and passenger friendliness and investigate the feasibility of these technologies and their integration"

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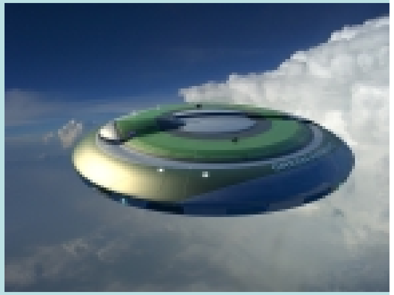

Objective

Development and integration of breakthrough technologies:

- Boundary layer control
- Parametric noise prediction model
- Autonomous flight control systems
- Advanced aircraft design with propulsion integration
- Knowledge based engineering
- Smart materials and composite design
- New structural designs

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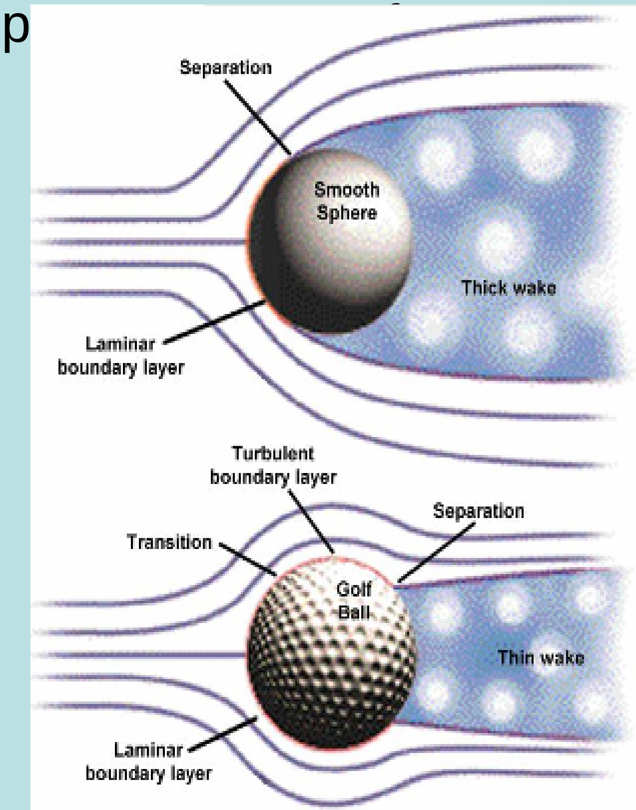
Boundary layer control

- Boundary layer control for drag reduction and p
  separation
- Passive control: surface treatment
- Active control: actuators, synthetic jets, riblets



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Parametric noise prediction model

- Current noise prediction models are based on semi-empirical theories $\rightarrow$ noise measurements done on conventional aircraft
- Need for a noise model based on the aircraft parameters: to evaluate new aircraft shapes

$\Rightarrow$ Using the parametric noise prediction model for the design of a revolutionary aircraft

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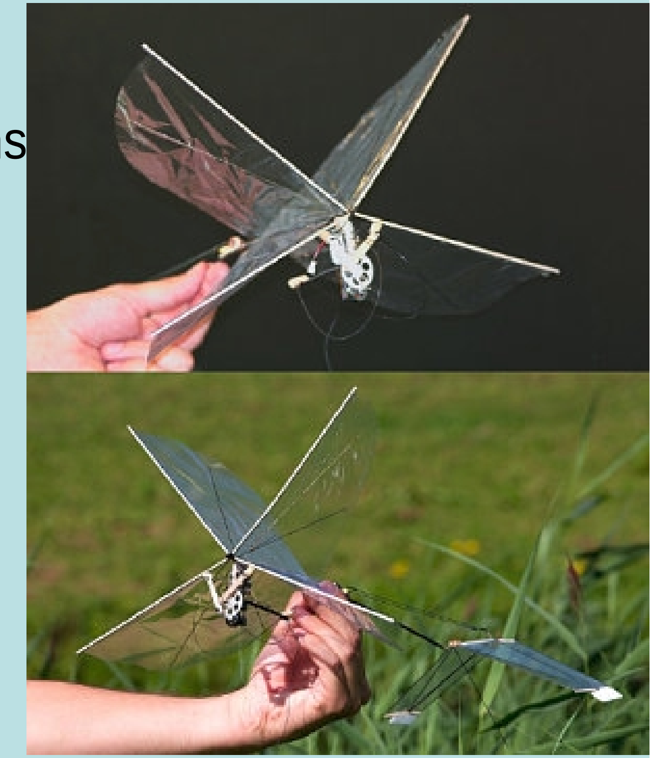
Autonomous flight control systems

- Advanced fly-by-wire systems
- Development of automatic flight control systems $\rightarrow$ elimination of the “loss of control in flight” human-induced accident factor
- Optimization of the human-machine interface
- Advances in flight control surfaces $\rightarrow$ elimination of the aircraft’s tail and reduction of control surfaces



Delfly

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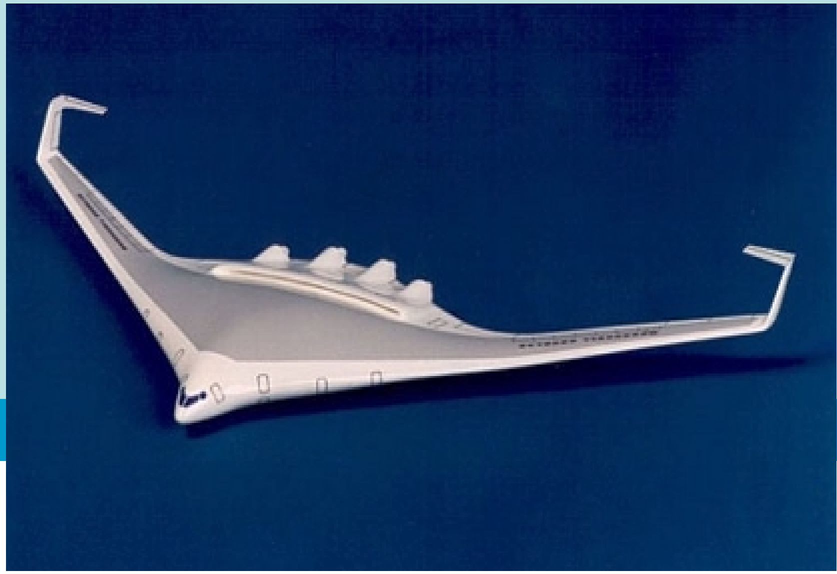
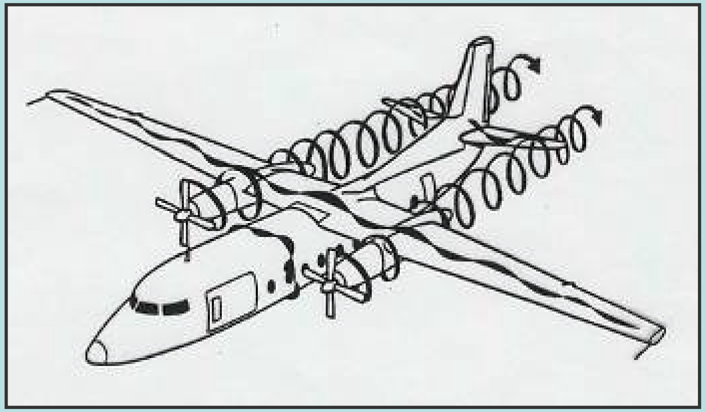
Advanced aircraft design with propulsion integration

- Integration of the propulsion system with the aircraft structure to optimize the efficiency and decrease noise → boundary layer ingestion motors
- Optimizing the position of the engine on the aircraft to reduce the interaction effects + modeling of these interaction effects
- Shielding of the engines to reduce the noise





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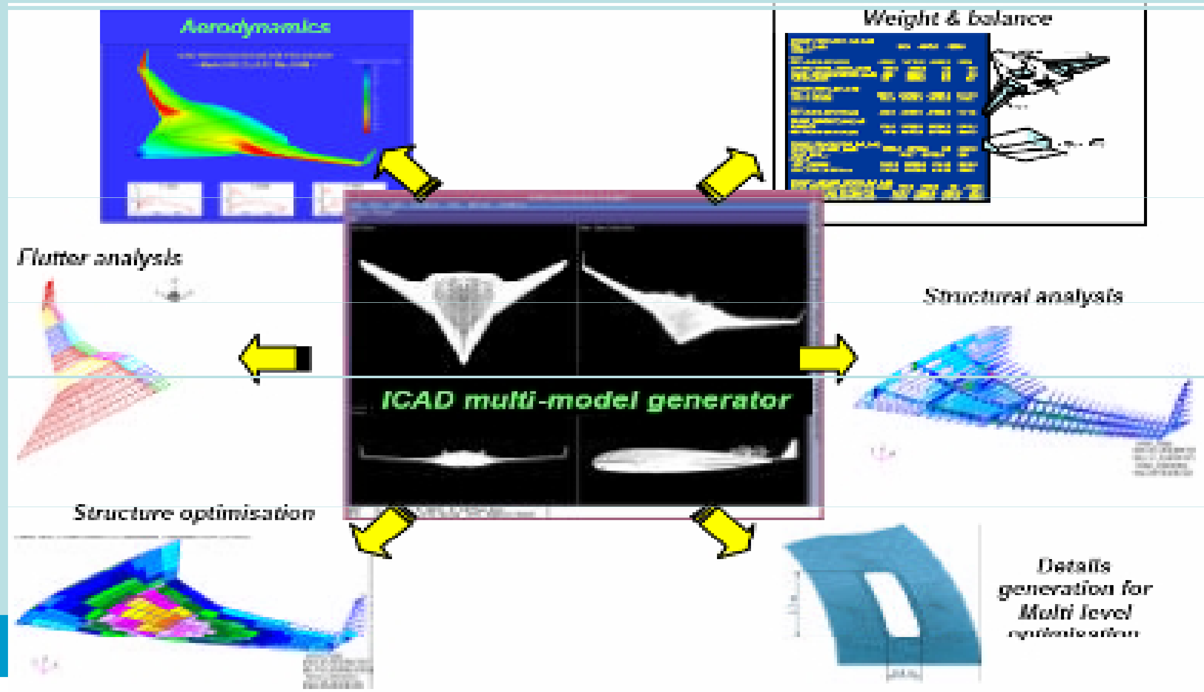
Knowledge based engineering

- KBE technology helps to structure and record knowledge in such a way that (engineering) knowledge becomes reusable, transferable and expandable
- Feature based modeling for detailed design: KBE approach to product modeling



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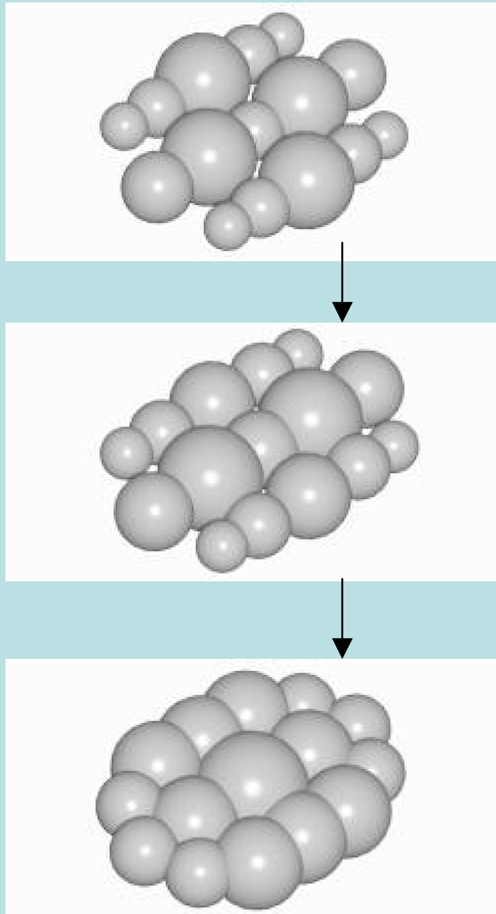
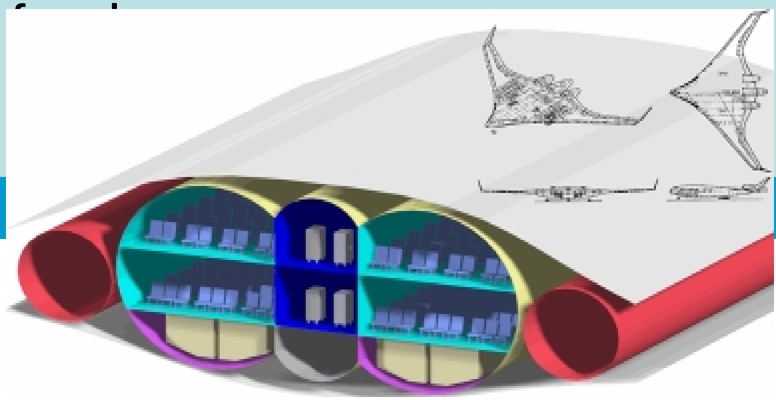
Smart materials and composite design



Clustering of flexible isotensoid pressure vessels to new multi-dome pressure fuselages for new blended wing bodies and lifting fuselages → Non-cylindrical composite



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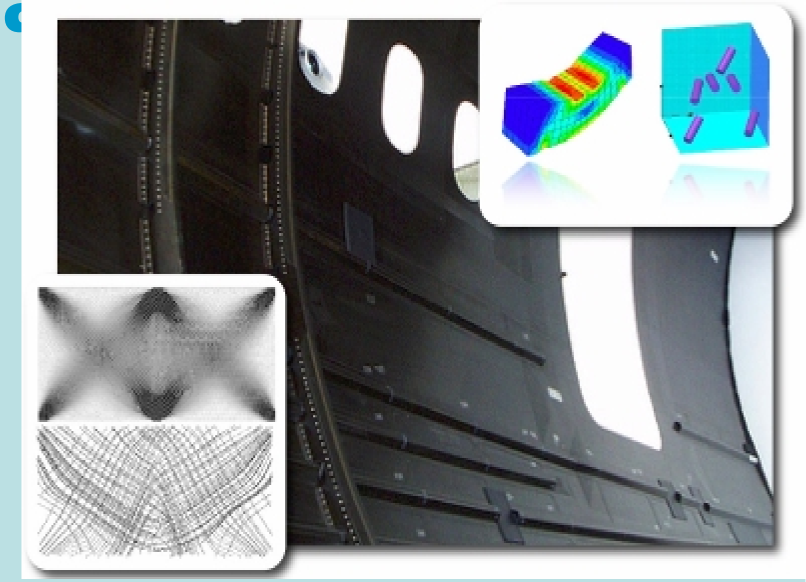
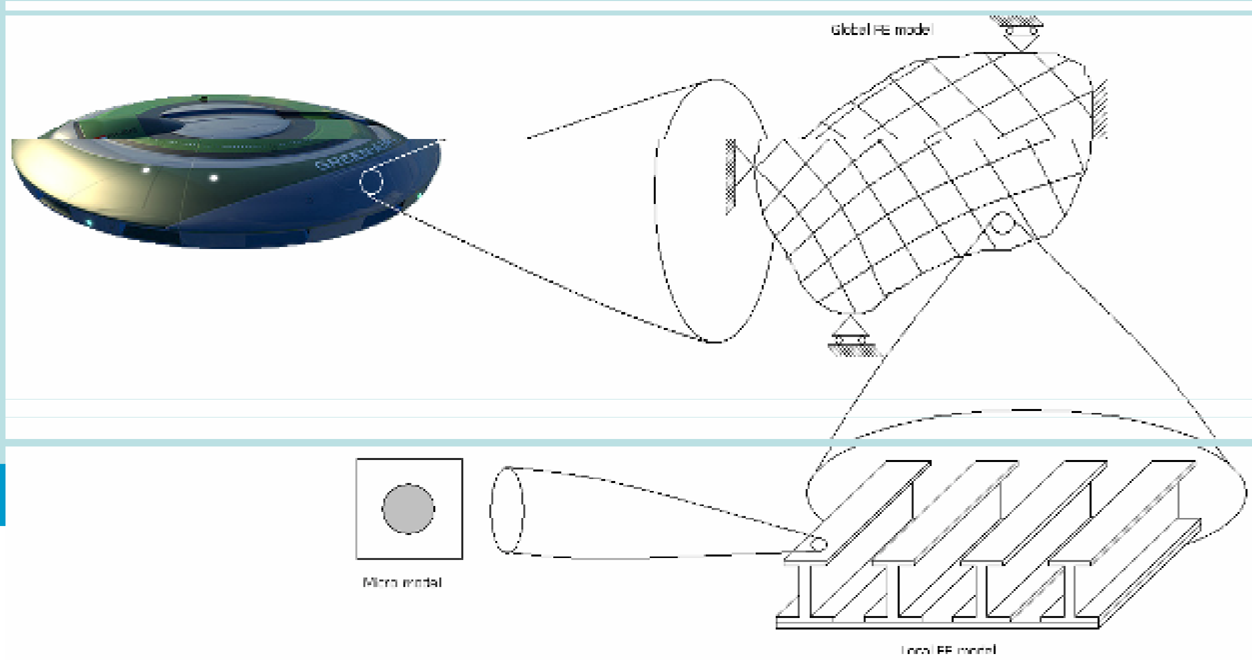
New structural designs

- “Fiber steered” grid stiffened panels → optimization of the composite for each panel
- Advanced non-linear global/local finite element analysis (and optimization development)





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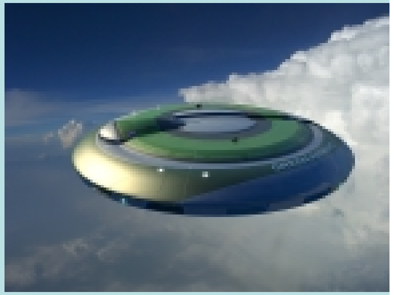

New break-through technologies and concepts need rethinking of regulations

For composites that are “tailor made”....

For new structural concepts......

For automated flight controls......

For “free flight” systems.....

For take-off and landing procedures.....

For aerodynamics based on boundary layer control.......

For ....

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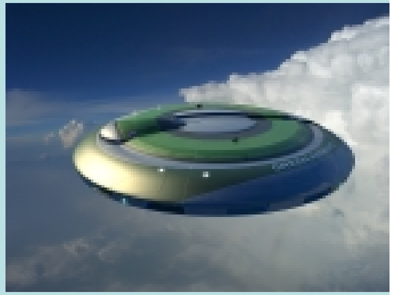
DELcraFT Works: CleanEra Project



Major partners

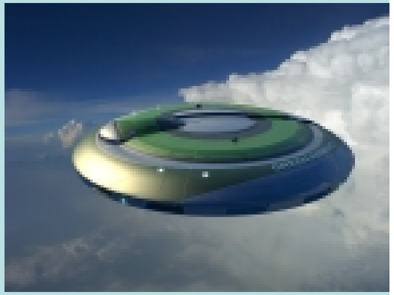
Royal Dutch Airlines

Stork Aerospace

Netherlands Agency for Aerospace Programmes

National Aerospace Laboratory

DELcraFT Works: **CleanEra Project**



Success Criteria for the 4 year project:

- Several breakthrough technologies are identified and feasibility is demonstrated
- preliminary designs can be presented
- aerospace industries and institutes are (very) interested in the results

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What will be CleanEra's future airplane concept

?

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We will let you know in 4 years!

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